5 Developing design criteria

So far, this thesis has examined the literature on games and learning and described a background study that was undertaken to examine the acceptability of this type of learning for students in Higher Education. This has provided a rationale for the use of computer game-based learning, but highlighted the importance of the games used being appropriate and seen as the most effective way to learn. This chapter examines the factors that can influence how pedagogically effective and usable a game-based learning application might be.

One of the aims of the overall research was to design, develop and compare two game-based learning applications, one that is essentially a computerised version of an existing classroom activity and one that is much more game-like, involving navigation of a virtual world and manipulation of objects within that world. As a starting point for designing these activities, it was important to recognise what constitutes good design, both in terms of educational effectiveness and also usability of the application. This chapter aims to present two sets of criteria that can be used to support the creation and evaluation of educational computer games.

First, existing design guidelines in related areas were reviewed and synthesised; these included the design of learning environments, multimedia learning design and game design. Secondly, an evaluation of a number of Internet games was carried out to examine their educational potential and interface characteristics. Finally, these two pieces of work were drawn together to produce two sets of criteria for the design of effective educational games, one focusing on learning design the other on the usability of the interface. The next section describes the evaluation of design guidelines that was undertaken.

5.1 Evaluation of design guidelines

This section presents a review of existing guidelines in three areas related to effective educational online game design: the design of learning environments; the design and use of educational multimedia; and the design of engaging computer-based activities. A short literature review of the guidelines produced in each of these areas is included in the following sub-sections.

5.1.1 Guidelines for designing constructivist learning environments

The currently dominant constructivist learning paradigm (as described in Chapter 2) holds that “learning is a process of people actively constructing knowledge” (Alessi & Trollip, 2001, p 32); certain games can be viewed as constructivist learning environments in that they provide opportunities for collaborative problem-solving in authentic contexts. If educational games are to be effective for supporting learning then it is important that they are underpinned by the principles of constructivist learning environments.

Alessi and Trollip (2001) present 14 principles that, they say, facilitate the production of knowledge from a constructivist view, while Savery and Duffy (1995) present eight instructional principles that in their view derive from constructivism. Hannafin and Land (1997) put forward 11 assumptions about student learning and provide examples of how these can be practically taken account of in constructivist environments, and Jonassen (1999) presents a framework for designing constructivist learning environments. The principles presented in these publications have been drawn together and are presented in the paragraphs that follow.

Active learning and critical thinking. Constructivist learning environments should support active and student-centred learning, by being designed to support and challenge the learner’s thinking, encouraging the testing of ideas against alternative views and in alternative contexts. Provision of multiple examples and interpretations to provide multiple perspectives should enable learner construction of information or projects and support learners to accept and reflect on the complexity of the real world.

Learner control and reflection. The emphasis within the environment should be on learning rather than teaching, and the actions and thinking of learners rather than teachers. Students should be given greater ownership of learning activities and the processes used to develop a solution as well as the end products. Learner choice, negotiation of goals, learning strategies and personal evaluation should be emphasised. Personal autonomy and reflection on the learning process should be encouraged on the part of the learners.

Authentic and collaborative learning. Learning activities should be collaborative or co-operative, purposeful, personally relevant to the learners and authentic, so that the learning from the activity is transferable to the real-life context. Activities within the learning environment should be designed to reflect the complexity of the environment in which they should be able to function at the end of learning, and learning activities should be anchored to a larger task or problem.

Supported learning. It is important that the process of learning in constructivist learning environments is supported throughout. Learners should be supported in developing ownership of the overall problem or task, and taking greater control of their learning over time through the use of scaffolding. Opportunities and support should be provided for learner reflection on both the content learned and the learning process, as well as by providing appropriate tools for learners to seek their own knowledge and the use of discovery or guided discovery approaches.

These principles of constructivist learning environments are incorporated in the criteria for developing effective computer-based learning activities in Section 5.3. The following sub-section provides an overview of the literature on multimedia learning and examines how it could support the design and development of educational computer games.

5.1.2 Guidelines for designing educational multimedia

In addition to a consideration of constructivist learning environments in the previous sub-section, an examination of the potential of multimedia to support learning is carried out in this sub-section. The majority of modern computer games make use of a range of media (e.g. audio, video, graphics, animation, virtual worlds), so it is therefore important to investigate the theories associated with multimedia learning in order to assess their application to computer game-based learning.

First, this sub-section describes some of the theoretical approaches that support the use of multiple media in learning, before examining a number of

sets of guidelines that are available in the literature and presenting a summary of factors that improve the educational potential of multimedia.

Dual coding theory (Paivio, 1991) hypothesises that there are two cognitive subsystems, one specialising in non-verbal information and the other dealing with language. Therefore presenting information simultaneously in verbal and non-verbal media should improve learning. Dual coding theory, although widely accepted, is still somewhat controversial and researchers (e.g. Clark & Craig, 1992) have argued that there is not enough evidence to support it.

Mayer (2001) provides evidence to support dual coding theory, brings together the work of himself and others in designing effective educational multimedia and describes a number of principles that are pertinent to its design and, by extension, the design of educational games that use multiple media. Mayer presents a range of multimedia effects, providing evidence that combining the use of words and pictures leads to better learning than using words alone and that the effects are increased when the words and pictures are closely proximal; that extraneous material is best excluded; that animation and narration support learning more than animation and on-screen text; and that design effects are stronger for high-spatial learners than for low-spatial learners, and for low-knowledge learners than for high-knowledge learners. This last finding was echoed by Najjar (1998), who also found evidence that educational multimedia is more effective with learners with low prior knowledge and low aptitude, that educational multimedia is more effective when learners are intrinsically motivated, and that multimedia improves learning more effectively as learners get older.

The theory of external cognition (Scaife & Rogers, 1996) highlights the importance of constructing external representations (e.g. diagrams, highlighting, notes) as an integral part of learning. They argue that the use of these additional external representations can reduce cognitive effort and ease problem-solving. This theory provides evidence of the theoretical educational benefits of interactive multimedia that supports the re-structuring, annotation and alternative representation of material to aid learning. In terms of multimedia

games, this type of external representation could include the use of overviews, notebooks, and maps.

Laurillard (1995) classifies educational multimedia into four types: narrative, discursive, interactive and adaptive; and argues that narrative is least good, and adaptive multimedia is best for supporting learning. Narrative multimedia presents information, and learning is supported through acquisition (e.g. print, video); discursive multimedia supports discussion and negotiation (e.g. tutorials, videoconferencing); interactive multimedia supports learning through discovery and trial-and-error (e.g. simulations); while adaptive multimedia supports learning through a process of guided discovery where the system supports and directs the learning process rather than leading it. It is clear that well-designed computer games have the potential to support discursive, interactive and adaptive learning models.

There is clear evidence for the use of multimedia to support learning, and several sets of guidelines also exist to support the design of effective educational multimedia.

Cates (1992) provides 15 principles for designing more effective multimedia products, while Park and Hannafin (1993) provide 20. Stemler (1997), Najjar (1998), and Lee and Boling (1999) all provide practical considerations of the educational characteristics of multimedia in terms of the user interface and multimedia elements used. The principles described in the following paragraphs are synthesised from they key factors drawn out of these sets of guidelines.

Presentation of information. To ensure effective presentation of information, use the medium that best communicates the information and adds value, use multimedia as a way of focusing and directing attention, and chunk information to aid readability. Use multiple media simultaneously, but aim to avoid information overload, and provide alternative ways of presenting and delivering information.

Visual design. To create an effective visual design keep the screen design clear, aesthetically pleasing, uncluttered and do not use multimedia in a decorative or gratuitous way. Ensure that navigation is obvious and consistent

throughout and that screen design and icon use are consistent. Create opportunities for the user to customise the look and feel of the application.

Support learning. In order to facilitate learning it must be ensured that the multimedia activity matches the intended teaching situation in terms of curriculum, practice and time and that the multimedia learning component is integrated with external tasks to encourage reflection and active processing of information. The interface should be meaningfully interactive and should provide indications of progress, and prompt, appropriate feedback. The application should encourage the development of meta-cognitive skills and provide opportunities for reflection, as well as catering for different levels of prior knowledge and providing structural aids to relate old and new knowledge.

As well as considering the fact that games generally are multimedia environments, it is important not to forget the basic usability principles that apply to the interface design of any computer-based application. Dix and colleagues (1997) describe three usability principles: learnability, the ease with which novice users of a system can use it; flexibility, provision of a range of ways for the user and system to interact; and robustness, the level of support required for successful goal achievement. Benyon and colleagues (2005) present ten usability principles, covering the areas of access, ease of learning and remembering, ease of use, safety and accommodating differences between people and respecting those differences.

The educational multimedia design principles and the usability principles described in this section are drawn together in Section 5.3, where two sets of criteria for evaluating the effectiveness of educational games are described. In the following sub-section guidelines for increasing engagement with educational activities are discussed.

5.1.3 Guidelines for designing engaging learning activities

This sub-section complements the guidelines discussed in the previous sub-section, by examining guidelines that exist for designing learning activities to be engaging.

Malone (1980a; 1980b) carried out some of the earliest work to examine factors that make games engaging. Despite being more than 25 years old, his work is still regularly cited today in papers on game design and engagement (e.g. Sandford & Williamson, 2005; Dickie 2006; Ebner & Holzinger, 2006). Malone argued that there were three factors that made games engaging: appropriate challenge; curiosity in the environment; and immersion in a fantasy. The additional factor of control over the environment was added after subsequent research (Malone & Lepper, 1987). Malone's findings were reported from work with children rather than adults but it still makes intuitive sense that an appropriate challenge that arouses curiosity while providing control over the environment could enhance engagement with adults; the idea of immersion in fantasy is perhaps less compelling.

Jones (1997) also puts forward a number of features of games that he argues lead to increased engagement, which could be applied to computer-based learning environments. He accepts that games do not engage all people, and focuses on the engagement factors in games for people who are engaged by games. The factors that he mentions that create engagement are: (a) production value – the design and look of the educational tool are very important, being fit for purpose but not gratuitous; (b) providing a mix of strategy and 'twitch' (i.e. thinking skills and motor skills), quick movement with immediate feedback coupled with strategy for a greater feeling of accomplishment and satisfaction; (c) 'thinking around corners', where answers are found through research and problem-solving; (d) the environment providing a safe place to learn from mistakes; and (e) immersion in new worlds through believable characters and circumstances, an illusion of reality, and controls that make sense relative to the reality. While it could be argued that many of these factors makes sense in an educational context, particularly as regards research and problem-solving, again it would be more difficult to argue that the use of 'twitch' or motor skills was appropriate to learning in Higher Education.

Lepper and Malone (1987) suggest a number of general principles for increasing the engagement and therefore effectiveness of learning. Their work was carried out with children so is not deemed to be wholly applicable to adults; only the aspects that are considered to be appropriate to adult learning are

included in the following discussion. Lepper (1998) also highlights a number of design principles for promoting intrinsic motivation for instruction and engagement with learning, while in a more recent study by Becta (2001a), a number of factors are described for increasing engagement with learning and for achieving sustained motivation. The principles discussed in these papers have been drawn together and are summarised in the paragraphs below.

Challenge. Learning environments should provide a range of challenges, increasing in difficulty. These challenges should be varied and have appropriate goals in that they are achievable and yet not easy or straightforward to achieve. The challenges should support research and problem-solving, and the motivational goals of completing the challenges must support the learning goals of the challenge (i.e. in order to complete a challenge it is necessary that the requisite learning takes place).

Stimulation. Engagement can be increased by stimulating curiosity by the provision of partial, incomplete or inconsistent information that encourages the learner to make sense of the situation, or by the use of multimedia effects to stimulate sensory curiosity. Applications that can stimulate and induce positive changes to the affective state of the learner are more likely to support learning.

Interaction. Active participation in a learning experience is more likely to engage the learners than passive involvement. Providing control over the learning environment, both in terms of what is being learned and the interface of the learning environment is important, as is regular, prompt and appropriate feedback showing the effects of actions and how near the learner is to the goal.

Contextualisation. To increase engagement, the learning activity must be seen as personally relevant to the user with a clear application of the learning to reality and a range of interaction controls that make sense in relation to reality.

The factors presented here are brought together with the principles highlighted in the previous two sub-sections, and the factors determined in the following section, in Section 5.3 to present two sets of criteria. The next section supplements the principles discovered from the literature by first-hand

evaluation and examines a number of games for their potential as learning environments, and the interface factors that enhance learning or engagement.

5.2 Review of existing games

In order to achieve a better first-hand understanding of the types of popular computer games available and to gain insights into the educational potential of different gaming types, an evaluation was carried out of existing computer games. This review aimed to gain an overview of the types of popular game available; examine the characteristics of these games that contributed positively or negatively to engagement; consider the potential of these entertainment games for education; and emphasise influences for the game-based learning activities to be produced as part of this research.

This review was intended to examine a relatively large number of games quickly to gain an overview of the potential and generate ideas, rather than study a small number of games in depth. Commercial games can be expensive, and are often time-consuming to install and sometimes require several hours of play to simply work through the tutorial, so for the purposes of this study it was decided to focus on freely available web-based games because they are generally quick to learn and to play and because there are a large number available with a wide variation of genre, interface, design and goals. Since this review aimed to examine some of the most popular games available at the time (2004), the Channel 4 Games web site (see http://www.channel4.com/games) was used as a starting point. This web site provides links to many hundreds of games in a variety of genres, which are rated and ranked by the user population.

A large number of web-based games were examined and 16 were selected for further evaluation, based on a number of criteria. The games selected had to be available free on the web, robust, with no obvious errors and continuously available over a period of time, of a type considered appropriate for educational potential (in general, the games selected focused on adventure, role-play, simulations and puzzles), and not solely designed for children.

In addition, for a game to be selected for inclusion in this review it had to manifest one or more characteristics that were considered to be worthy of

further investigation in terms of educational value or interface design. The web addresses of the games used are available in Appendix 5. Each game was played by the researcher for a minimum of 20–30 minutes before noting areas in which the game has educational potential, elements of the game and interface design that were positively or negatively motivational and ideas from the interface that were seen to be useful or innovative and could be implemented in the game-based applications developed as part of this research. Although the views expressed here are clearly the opinions of a single individual, this part of the research was intended to complement the literature reviews already carried out rather than to be used discretely.

Avatar High is a virtual high school simulation game in which the player has to juggle school and friendships. It has educational potential for teaching interpersonal interactions as well as organisational skills by juggling a number of variables simultaneously. It contains a large degree of interactivity, with multiple possible paths through the game, and the graphics are of a high quality. However, it is difficult to get started, the goals are not clear and there is distracting background music.

Bookworm is a word-builder puzzle game, which could be used to teach writing skills such as spelling or vocabulary. It has a simple premise and game design with increasing difficulty and additional features to keep the player engaged. Sound and animation are used but in a limited and appropriate way. Context-sensitive help is provided and there are alternative methods of interaction available. On the negative side, the game is very repetitive and could get boring quickly and may have limited scope.

Bootlegger is a trading simulation that has potential application in teaching basic economics, cause and effect, or the assimilation and use of multiple sources of information. The game makes use of a simple underlying model and it encourages exploration of this model through use of an innovative theme and the addition of occasional events to add interest. However, the usability of the interface is poor, the functionality is not clear and the help is not easy to find and use. The game is also not sufficiently challenging as there is no clear goal and winning or losing is based on a few actions early on in the game.

The Crimson Room is an adventure in which the player must solve puzzles to escape from a series of locked rooms, using the mouse to interact with objects (known as a point-and-click adventure). The potential educational value lies in the areas of lateral thinking and problem-solving. The game has a confusing start but in this case it sets the scene and encourages exploration. The mystery theme is compelling and the game uses simple, but effective, graphics. However, the lack of instructions could be off-putting to a novice, some of the puzzles are obscure, it is easy to miss objects, not straightforward to see what objects can be interacted with, and easy to get stuck and frustrated.

Grow is a puzzle game that encourages learning by trial and error, experimentation and evaluation. It is a very simple game, yet engaging, unique and original, with many correct solutions. However, the goals of the game are not clear (although discovering them is part of the game) and once the game has been solved it is not really repeatable.

Hamlet is a text-based adventure game based around the Shakespeare play. Educationally, it could be used to enable immersion in the plot of Hamlet. The game has a simple interface, but assumes previous knowledge of text adventures, although hints are provided. Because there are no graphics in the game it relies on the story and the game design for engagement. On the negative side, game commands need to be memorised and typing can become slow and repetitive. It is difficult to visualise the game without graphics.

iSketch is a multi-player computer-based version of the popular game Pictionary in which players have to guess what objects other players are drawing. Its educational applications could include teamwork and co-operation, vocabulary, and teaching appropriate behaviour in a social environment. The game involves playing with real people worldwide in a self-regulating community in which everyone gets a chance to participate and there is no need to divulge personal information. There are many options on types of game and levels of difficulty as well as provision of a practice area.

Laser beams is a logic puzzle that involves moving objects to direct lasers. It has applications in logic and problem-solving as well as applying learned rules

to novel situations. The game provides a large selection of puzzles of increasing difficulty but that can be completed in any order; each puzzle has an explicit goal. The first few levels of the game take the role of a tutorial. However, the puzzles do quickly start to become repetitive.

Law and Order II is a mystery adventure game that involves playing the part of a New York crime scene investigator to solve a murder. Educational applications could include teaching of crime scene procedure or problem-solving. The game provides a clear interface, rich in functionality, with use of high-quality audio, video, graphics and other multimedia elements. A negative point is that it is difficult to slow down or speed up the game, which is at times frustrating.

Lemonade is a simple business simulation about running a lemonade stall; it could be used to teach basic economic principles. The game is based on a simple model and enables players to evaluate different strategies (e.g. cost over quality). However, this site contains distracting banner advertising and colour combinations that are hard on the eye.

Mini golf is a multi-player crazy golf simulation. It has educational potential in terms of the simple physics of objects or social interaction. The game is simple to start, but difficult to master, with improvement as the player becomes more skilled. There is ongoing performance feedback as well as a score and there is a best-score board to gauge performance against all players. However, the game is limited to two players, the chat can be distracting to the game and it is frustrating when a single poor hole can affect the entire game.

The Mystery of Time and Space is a point-and-click adventure game, with the potential to teach lateral thinking or problem-solving. It uses simple, but effective graphics, provides the ability to save the game, provides immediate feedback to actions (both on rollover and click) and enables players to chat with other people playing the game. However, the help menu is difficult to find and navigate, some puzzles are difficult and not always logical, and it is possible to achieve things through trial and error without understanding why.

Runescape is a multi-user role-playing game with the potential to teach collaboration, negotiation and other interpersonal skills. It has high levels of interactivity and possible paths of action in a vast virtual world, and is rich in functionality. Characters in the game can be personalised to a high degree but players have to sign up and create usernames. While there is a lot of functionality, the game environment and interface are complex and learning times high.

Samorost is a point-and-click adventure, with potential for teaching problem-solving, which is most notable for its beautiful and unique graphics, originality and intriguing nature. On the negative side, puzzles can not always be solved logically but can be solved through random clicking, there is a lack of feedback and the goals are not clear.

Typer Shark is a typing tutor, designed to teach keyboard skills. It provides clear, attainable, ongoing goals with increasing difficulty. There are statistics at the end of each round and bonuses and regular feedback on accuracy. However, the game is highly repetitive (although that is the nature of the skill being taught) and soon becomes boring. The time constraints add pressure to the game.

Whizzball is a puzzle environment in which a range of objects are used to move a ball across a board. It has potential for teaching creativity and problem-solving. As well as playing existing puzzles it provides the ability to create new ones and share them with a community, where they are rated by other members of the community. In this way the game caters for a whole range of ability. A negative point is that the player cannot develop outside of the system, for example by creating new tools rather than manipulating ones that exist.

Table 5-1 below shows the best characteristics that were seen in each game, which were input into the design criteria developed in the following section and influenced the design of the two game-based learning applications discussed in Chapter 6.

Game	Best characteristics
Avatar High	High level of interactivity. Use of avatars.
Bookworm	Ongoing context-sensitive help. Increasing difficulty and gradual addition of new features. Different ways to interact with the environment.
Bootlegger	Based around a strong and compelling theme.
The Crimson Room	Simple but effective graphics. Encouragement of exploration. Interaction with objects.
Grow	Explorative and provides mystery. Many possible solutions.
Hamlet	Provision of hints and clues. Strong plot and storyline.
iSketch	Player regulation of the environment. Provision of a practice area. Equal opportunity for all in the team to participate anonymously.
Laser beams	Control over order in which game can be completed. Clear goals at each stage of the game. Integrated tutorial area.
Law and Order II	As high quality multimedia as possible. Rich range of functionality. User control of speed.
Lemonade	Simple but compelling basic game design.
Mini golf	Competition with others. Ongoing feedback regarding performance. Easy to start, with increasing difficulty. Steady improvement.
The Mystery of Time and Space	Support from player group. Save game function. Immediate and intrinsic feedback to actions performed on objects.
Runescape	Many possible paths of action. Large world to be explored. Ability to collaborate or compete with others. Personalisation of characters.
Samorost	Mysterious and original. Stimulates curiosity.
Typer Shark	Increasing difficulty. Performance indicators built in to the game. Regular feedback on performance.
Whizzball	Possibility for extending game by creating new levels. Sharing levels with online community.

Table 5-1: Best characteristics from the 16 games reviewed

The examination of these games revealed a number of design principles that supported game play, interface design, engagement, and the potential for learning. These factors are discussed in the following paragraphs.

Game design. Features of game design that were seen as supporting playability and providing the best environment for learning were provision of a multi-player puzzle adventure game with a large world to be explored and a high level of interactivity with characters and objects, based around a theme

with a strong plot and storyline, with multiple possible ways to complete the game, not just a single solution. The game should also have a mystery and explorative element, aiming to make it surprising, original and motivating, and involve elements of competition and collaboration. In terms of support for learning the game, it should provide a training environment where users can learn the game while starting to play but with no consequences, and ongoing context-sensitive help, hints and clues.

Engagement. There are a number of factors that increased engagement, including clear goals at each stage of the game, group and individual, and sub-goals as well as main goals, and performance indicators built into the game and regular feedback on performance provided. The game should be easy to start but with increasing difficulty and addition of new features; players should quickly be able to achieve initial goals and see improvement in performance. The ability to save games should be provided so that progress is not lost. In addition, the use of avatars enables the players to personalise their characters without the need to give away lots of personal information.

Interface design. In terms of the design of the interface, there are a number of lessons that can be learned from this game review. The interface should provide a rich range of functionality and provision of different ways to interact with the environment with player control over which objects or people to interact with and ways in which the game can be completed. It should be apparent what functionality objects posses and provide immediate feedback on actions performed. Graphics should be simple but effective with as high quality multimedia as possible where appropriate (within the limitations of the development and runtime environments).

Educational design. Features that were identified that increased the educational potential of the games examined were the ability of the game to foster learning through problem-solving, decision-making and group interaction, where the game is designed to encourage players to solve problems and work through the game as a group, using online communication media. The environment should also aim to encourage exploration and discovery, possibly with interaction with external web sites. All players should have the opportunity

to interact with the environment and learn to the same potential degree, and social norms and acceptable behavioural standards should be primarily self-regulated.

In the following section these principles are drawn together with the guidelines presented in the previous section to present two sets of criteria for the educational design and interface design of effective game-based learning applications.

5.3 Criteria for designing educational computer games

In this final section of this chapter, the guidelines discussed in Section 5.1 are combined with the factors highlighted in Section 5.2 to produce two sets of objective criteria for the design of game-based learning applications: the first addressing the aspects of the educational design that increase effectiveness for learning, and the second dealing with those elements of the interface design that influence the effectiveness of the application for learning.

Games that are effective for learning are those that apply sound pedagogic principles that are appropriate for the subject being taught. Games that involve problem-solving and constructing an individual understanding, active exploration, collaboration with others and authentic activities supporting the development of skills and knowledge that can be transferred to other situations are those most likely to be effective in an educational context. A variety of game genres, including adventure games, role plays, puzzle or simulation games, commonly have these characteristics.

The first set of criteria consists of six areas that can be used to evaluate the educational design of a game-based learning application. These areas are: the ability of the application to support active learning, the degree to which it is designed to engender engagement, the appropriateness of the application for the learning outcomes to be taught, the degree to which it supports reflection, the extent to which it provides an equitable experience for all participants, and the availability of ongoing support. These criteria are shown in Table 5-2 below.

Criteria	Elements that support fulfilment of the criteria
Supports active learning	Encourages exploration, problem-solving, enquiry. Opportunities for collaboration. Opportunities to test ideas and gain feedback. Opportunities for practice and consolidation. Game goals align with learning goals.
Engenders engagement	Clear and achievable goals throughout. Large world to be explored. High level of interactivity. Multiple possible ways to complete. Stimulates curiosity. Appropriate challenge. Provides control over the learning environment.
Appropriateness	Fits with curriculum and assessment. Appropriate for subject matter. Matches time available. Personally relevant for students.
Supports reflection	Opportunities for reflection. Debriefing on learning. Highlights process of learning.
Provides equitable experience	Accounts for differing prior knowledge. Allows for customisation. Provides equal opportunities to participate.
Provides ongoing support	Orientation and overview. Quick initial success. Gradual introduction of complexity. Hints and clues.

Table 5-2: Criteria for the effective educational design of game-based learning applications, and elements that support fulfilment of each criterion

As well as defining a set of criteria to support educational design, a second set was developed focusing on the interface design of game-based learning applications. This second set of six criteria examines whether the user interface, elements used and interaction models facilitate learning: flexible ways for the user to interact with the environment, support for the development of a collaborative player community, transparent navigation features, features that support the user control of the environment, robustness of design, and appropriate visual design. These criteria are shown in Table 5-3 below.

Criteria	Elements that support fulfilment of the criteria
Flexible interaction	Interaction is purposeful. Feedback is timely and meaningful. Controls are logical and consistent. Performance indicators are built in. Range of interaction methods available.
Support for player community	Self-regulation functionality. Use of avatars. Integrated communication tools.
Transparent navigation	Navigation clear and consistent. Alternative methods of navigation. Help functionality obvious. Overview of position in environment.
User control	Pace and level adjustable. Customisation options. Tasks can be undertaken in any sequence. Instructions obvious and clear. Appropriate and obvious functionality.
Robustness	Recovery from errors. Responsive to input. Context-sensitive help and hints. Ability to save.
Appropriate visual design	Simple, uncluttered and aesthetically pleasing. Information in accessible chunks. Consistent placement between screens. Graphics and multimedia purposeful. Text legible. Pleasing colour scheme.

Table 5-3: Criteria for the effective interface design of game-based learning applications, and elements that support fulfilment of each criterion

This chapter has used both secondary and primary research to develop and present these two sets of criteria to evaluate the elements of educational and interface design that influence the appropriateness of a computer game-based activity for learning. Initially, a review was provided pulling together research on the design of learning environments, principles of multimedia for learning and design of engaging learning activities. Secondly, a first-hand evaluation of 16 online games is described and features in their design discussed.

The following chapter describes the use of the first set of criteria as a basis for designing two game-based learning applications. The second set of criteria was used to evaluate the interfaces of the applications produced, and this is described in Chapter 7.